

# Observing Chemical Change

## Reading Preview

### Key Concepts

- How can matter and changes in matter be described?
- How can you tell when a chemical reaction occurs?

### Key Terms

- matter • chemistry
- physical property
- chemical property
- physical change
- chemical reaction • precipitate
- endothermic reaction
- exothermic reaction

## Target Reading Skill

**Asking Questions** Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, write the answers to your questions.

### Properties and Changes of Matter

Question	Answer
What are physical properties of matter?	Physical properties are . . .

Chemical change can lead to a treat. ►

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## Discover Activity

### What Happens When Chemicals React?

1. Put on your safety goggles. Place 2 small spoonfuls of baking soda into a clear plastic cup.
2. Holding the cup over a large bowl or sink, add about 125 mL of vinegar. Swirl the cup gently.
3. Look at the material in the cup. What changes do you see? Feel the outside of the cup. What do you notice about the temperature?
4. Carefully fan the air above the liquid toward you. What do you smell?

### Think It Over

**Observing** What changes did you detect using your senses of smell and touch?

Picture yourself toasting marshmallows over a campfire. You see the burning logs change from a hard solid to a soft pile of ash. You hear popping and hissing sounds from the fire as the wood burns. You smell smoke. You feel the heat on your skin. Finally, you taste the results. The crisp brown surface of the toasted marshmallow tastes quite different from the soft white surface of a marshmallow just out of its bag. Firewood, skin, and marshmallows are all examples of matter. **Matter** is anything that has mass and takes up space. The study of matter and how matter changes is called **chemistry**.





# Properties and Changes of Matter

Part of studying matter is describing it. When you describe matter, you explain its characteristics, or properties, and how it changes. **Matter can be described in terms of two kinds of properties—physical properties and chemical properties.** Changes in matter can be described in terms of physical changes and chemical changes.

**Properties of Matter** A **physical property** is a characteristic of a substance that can be observed without changing the substance into another substance. The temperature at which a solid melts is a physical property. For example, ice melts at a temperature of zero degrees Celsius. Color, hardness, texture, shine, and flexibility are some other physical properties of matter. The ability of a substance to dissolve in water and how well it conducts heat and electricity are examples of still more physical properties of matter.

A **chemical property** is a characteristic of a substance that describes its ability to change into other substances. To observe the chemical properties of a substance, you must change it to another substance. For example, when magnesium burns, it combines with oxygen in the air, forming a new substance called magnesium oxide. People who make objects out of magnesium must be careful because the metal can catch fire. Burning is only one type of chemical property. Other examples of chemical properties are tarnishing and rusting.

FIGURE 1

## Properties of Water

This geyser gives off hot water and water vapor, which condenses into a visible cloud in the cold air. The temperatures at which water boils and freezes are physical properties of water.

**Predicting** How will the snow change when spring arrives?

### Chemical Properties of Water

- Made of hydrogen atoms and oxygen atoms in a 2 to 1 ratio
- Does not burn
- Reacts with some metals

### Physical Properties of Water

- Clear, colorless liquid at room temperature
- Boils at 100°C
- Freezes at 0°C





#### Physical Change

You can flatten and pull on a marshmallow but its composition will stay the same.



#### Chemical Change

If you toast a marshmallow, the sugars and other substances will cook or burn, producing a crust made of new substances.

FIGURE 2

### Changes in Matter

Matter can undergo both physical change and chemical change.

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## Skills Activity

### Classifying

Classify each of the following changes as either a chemical change or a physical change. Explain your reasoning for each case.

- A piece of metal is heated to a high temperature and changes to a liquid.
- When two solutions are poured into the same container, a powdery solid forms and settles to the bottom.
- Water left in a dish overnight has disappeared by the next day.
- A blacksmith hammers a piece of red-hot iron into the shape of a knife blade.

**Changes of Matter** You probably have seen solid water (ice) change to liquid water. Water is the same substance, whether it is frozen or liquid. Therefore, changing from a solid to a liquid is a physical change. A **physical change** is any change that alters the form or appearance of a substance but that does not make the substance into another substance. You cause a physical change when you squash a marshmallow. The shape of the marshmallow changes but not the taste! It's still made of the same compounds that have the same properties. Other examples of physical changes are bending, crushing, breaking, cutting, and anything else that changes only the shape or form of matter. Braiding your hair is another example of a physical change.

Sometimes when a change occurs in a substance, the substance itself is changed. For example, the brown crust on a toasted marshmallow is the result of sugar changing to different substances in a mixture called caramel. A change in matter that produces one or more new substances is a chemical change, or **chemical reaction**. The burning of gasoline in a car's engine is a chemical change. The new substances formed end up as the car's exhaust.



What kind of change occurs when you toast the outside of a marshmallow?



**Bonding and Chemical Change** Chemical changes occur when bonds break and new bonds form. As a result, new substances are produced. You may recall that atoms form bonds when they share or transfer electrons. The reaction pictured in Figure 3 involves both the breaking of shared bonds and a transfer of electrons.

Oxygen gas ( $O_2$ ) in the air consists of molecules made of two oxygen atoms that share electrons. These bonds are broken when oxygen reacts with magnesium metal (Mg). Each magnesium atom transfers two of its electrons to an oxygen atom. The oxygen atom becomes a negative ion, and the magnesium atom becomes a positive ion.

You can probably guess what happens next. You may recall that oppositely charged ions attract. An ionic bond forms between the  $Mg^{2+}$  ions and the  $O^{2-}$  ions. The ionic compound magnesium oxide (MgO) is produced, and energy is released. Magnesium oxide—a white, crumbly powder—has properties that differ from those of either shiny magnesium or oxygen gas. For example, while magnesium melts at about  $650^\circ C$ , it takes temperatures of more than  $2,800^\circ C$  to melt magnesium oxide!

Go Online

SciLinks™

For: Links on chemical changes

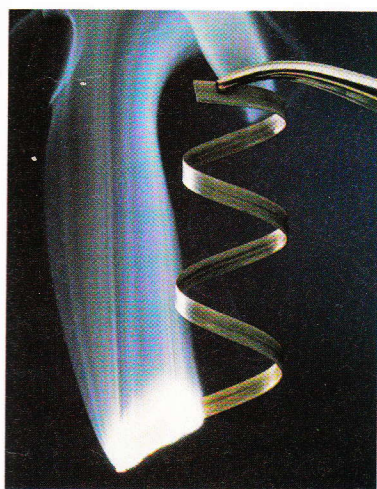
Visit: [www.SciLinks.org](http://www.SciLinks.org)

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FIGURE 3

**Bonding and Chemical Change**

As magnesium burns, bonds between atoms break and new bonds form. The reaction gives off energy. **Interpreting Diagrams** Why does the oxygen ion have a 2- charge?

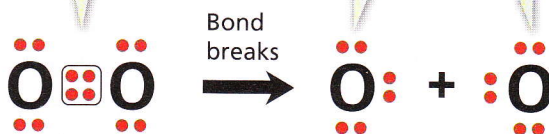


▲ Magnesium and oxygen react.

**1** Oxygen bonds break.

An oxygen molecule has a double bond.

Each oxygen atom can accept two electrons.

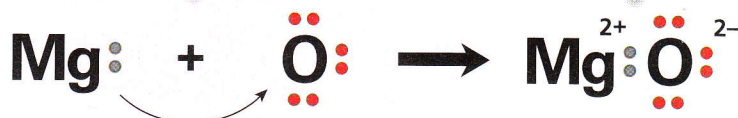


▲ Magnesium oxide forms.

**2** Magnesium and oxygen combine.

A magnesium atom loses two electrons to an oxygen atom. Oppositely charged ions form.

An ionic bond forms between the oppositely charged ions.





## Evidence for Chemical Reactions

Look at the photograph below of the beaker. Even without reading the caption, you probably could guess it shows a chemical reaction. But how do you know? How can you tell when a chemical reaction occurs? **Chemical reactions involve two main kinds of changes that you can observe—formation of new substances and changes in energy.**

**Changes in Properties** One way to detect chemical reactions is to observe changes in the properties of the materials involved. Changes in properties result when new substances form. What kinds of changes should you look for? Look at Figure 4. First, a color change may signal that a new substance has formed. Second, a solid may appear when two solutions are mixed. A solid that forms from solution during a chemical reaction is called a **precipitate** (pree SIP uh tayt).

FIGURE 4

### Evidence for Chemical Reactions

Many kinds of change provide evidence that a chemical reaction has occurred.

**Applying Concepts** What other evidence might tell you a chemical reaction has occurred?



Two clear liquids react, ▲ forming a precipitate.

▶ The light green leaves of early spring slowly turn darker as chemical reactions in the leaves produce more of the green compound chlorophyll.





Third, a gas might be produced from solids or liquids. If the reaction occurs in a liquid, you may see the gas as bubbles. Finally, other kinds of observable changes in properties can also signal a chemical reaction. For example, moist bread dough forms a dry, porous solid after baking.

Although you may observe a property change in matter, the change does not always indicate that a chemical reaction has taken place. Sometimes physical changes give similar results. For example, when water boils, the gas bubbles you see are made of molecules of water, just as the original liquid was. The sign of a chemical reaction is that one or more new substances are produced. For example, when an electric current is passed through water during electrolysis, two gases are produced, hydrogen gas ( $H_2$ ) and oxygen gas ( $O_2$ ).



**Reading  
Checkpoint**

How is a precipitate evidence for a chemical reaction?

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## Try This Activity

### Mostly Cloudy

1. Put on your safety goggles and apron.
2. Pour about 5 mL of limewater into a plastic cup.
3. Pour an equal amount of plain water into another plastic cup.
4. Add about 5 mL of carbonated water to each of the cups.

**Drawing Conclusions** In which cup do you think a chemical reaction occurred? What evidence supports your conclusion?

A golden loaf of bread with its crunchy crust has very different properties from the soft dough that went into the oven. ▼



Oxygen bubbles that form during photosynthesis collect on the leaves of a plant. ▼



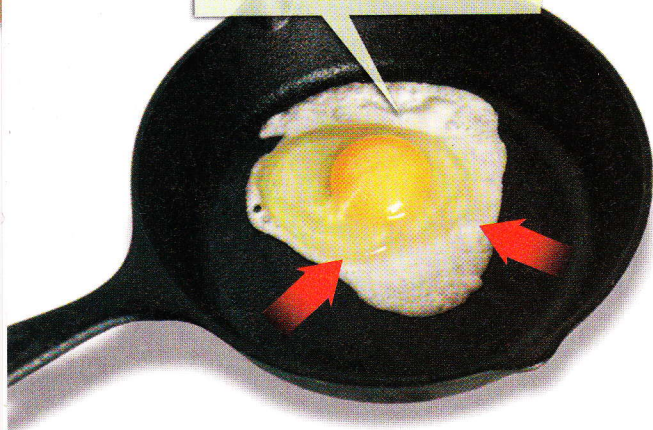


FIGURE 5

### An Endothermic Reaction

Energy must be added continuously to fry an egg. **Making Generalizations** In terms of energy, what kind of reaction usually occurs when food is cooked?

Energy can change egg whites from a clear liquid into a white solid.



**Changes in Energy** From your everyday experience, you know about various types of energy, such as heat, light, and electricity. As matter changes, it can either absorb or release energy. A change in energy occurs during a chemical reaction. Some reactions absorb energy, while others release energy. One common indication that energy has been absorbed or released is a change in temperature.

If you did the Discover activity, you observed that the mixture became colder. When baking soda (sodium bicarbonate) reacts with vinegar, the reaction takes heat from the solution, making it feel cooler. This kind of reaction is an example of an endothermic reaction. An **endothermic reaction** (en doh THUR mik) is a reaction in which energy is absorbed. However, endothermic reactions do not always result in a decrease in temperature. Many endothermic reactions occur only when heat is constantly added. For example, the reactions that occur when you fry an egg are endothermic.

## Math

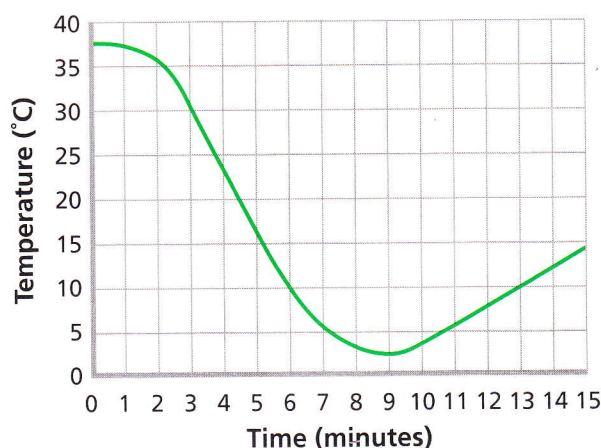
### Analyzing Data

#### Energy in Chemical Changes

A student places two substances in a flask and measures the temperature once per minute while the substances react. The student plots the time and temperature data and creates the graph at right.

- Reading Graphs** What was the temperature in the flask at 4 minutes? When was the first time the temperature was  $6^{\circ}\text{C}$ ?
- Calculating** How many degrees did the temperature drop between 2 minutes and 5 minutes?
- Interpreting Data** Is the reaction endothermic or exothermic? Explain.
- Inferring** At what temperature did the reaction stop? How can you tell?

#### Energy of a Chemical Reaction



- Drawing Conclusions** Suppose the temperature in the flask increased instead of decreased as the reaction occurred. In terms of energy, what kind of reaction would it be? Explain.



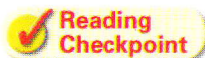
FIGURE 6

### An Exothermic Reaction

Enough energy is released by the burning of airplane fuel to keep a plane moving fast enough to fly.



In contrast, the reaction between fuel and oxygen in an airplane engine releases energy, mostly in the form of heat. The heat causes gases in the engine to expand. The expansion and movement of the gases out of the plane exerts a force that moves the plane forward. A reaction that releases energy in the form of heat is called an **exothermic reaction** (ek soh THUR mik). You will learn more about energy and chemical changes in Section 3.



Reading  
Checkpoint

What is an endothermic reaction?

## Section 1 Assessment

**Target Reading Skill Asking Questions** Use the answers to questions you wrote about the headings to help you answer the questions below.

### Reviewing Key Concepts

1. a. **Explaining** What is the difference between the physical properties and the chemical properties of a substance?
- b. **Posing Questions** When silver coins are found in ancient shipwrecks, they are coated with a black crust. What question could you ask to help you decide whether the silver underwent a chemical change or a physical change? Explain.
- c. **Making Generalizations** In terms of chemical bonds and electrons, what kinds of changes occur between atoms when substances undergo chemical reactions?

2. a. **Listing** What are five kinds of evidence you can use to determine if a chemical reaction has occurred?
- b. **Interpreting Photographs** How do the properties of the cooked egg shown in Figure 5 differ from the properties of a raw egg?
- c. **Comparing and Contrasting** How are endothermic and exothermic reactions the same? How are they different?

### Writing in Science

**Persuasive Letter** Imagine you have a pen pal who is studying chemistry just like you are. Your pen pal claims the change from liquid water to water vapor is a chemical change. Write a brief letter that might convince your pen pal otherwise.